LAND COVER THEMATIC MAP PRODUCTION BY PHOTOINTERPRETATION AND QUANTITATIVE ANALYSIS OF SATELLITE IMAGERY

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ABSTRACT

Remote Sensing makes possible to monitor and observe extensive geographical areas economically. Unlike Photogrammetric data, Remote sensing data are only in digital form. These data are used for the measurement of both geometric and thematic properties of earth's environment from a distance. Thematic maps are currently used in many studies such as environmental monitoring, tectonic fault/fold observations, etc. Thematic maps are generated in two ways: either manually by photointerpretation, or automatically using a classification procedure. The objective of this paper is to use both ways to produce a land cover map, evaluate and comment the resulting maps. For the purpose of this paper we used a part of a multispectral LandSat TM imagery over the Greek Island of Lesvos. To perform the photointerpretation task the MAPINFO GIS was used. The automatic land use classification was carried out using the "Artificial Neural Networks for GEOSIS Integrated Environment (ANNGIE)", developed by National Research Center "DEMOKRITOS" in the framework of Geonickel BRITE EURAM project. Results show that both approaches of thematic map generation have their own purpose and are often complementary.

ΠΕΡΙΛΗΨΗ

Η Τηλεανίχνευση επιτρέπει την παρατήρηση εκτεταμένων γεωγραφικών περιοχών χρησιμοποιώντας δεδομένα που είναι σε ψηφιακή μορφή. Οι θεματικοί χάρτες χρησιμοποιούνται σε πολλές μελέτες όπως είναι οι περιβαλλοντικές, γεωτεκτονικές κτλ. και δημιουργούνται με δύο τρόπους: είτε χειρονακτικά μέσω φωτοερμηνείας, είτε αυτόματα χρησιμοποιώντας διαδικασία ταξινόμησης.
Σκοπός της εργασίας αυτής είναι η χρησιμοποίηση των δύο παραπάνω μεθόδων για τη δημιουργία χάρτη χρήσεων γης, σύγκρισης και σχολιασμού των αποτελεσμάτων. Για τις ανάγκες της εργασίας αυτής χρησιμοποιήσαμε ένα τμήμα της πολυφασματικής LandSat TM εικόνας που καλύπτει τμήμα της νήσου «Λέσβος». Τα αποτελέσματα της φωτοερμηνείας επεξεργάστηκαν στη συνέχεια με το GIS MapInfo. Η αυτόματη ταξινόμιση των χρήσεων γης έγινε με τη χρησιμοποίηση του αλγορίθμου "Artificial Neural Networks for GEOSIS Integrated Environment (ANNGIE)", που κατασκευάστηκε στο Εθνικό Ερευνητικό κέντρο "Δημόκριτος". Τα αποτελέσματα έδειξαν ότι και οι δύο προσεγγίσεις της θεματικής χαρτογράφισης συχνά αλληλοσυμπληρώνονται.

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INTRODUCTION

When image data are available in digital form there are 2 approaches that may be adopted to extract information. One involves a human analyst/interpreter extracting information by visual inspection of an image composed from the image data. In this, he or she knows generally large scale features and is often unaware of the spatial and radiometric digitization of the data. This is called "photointerpretation" or sometimes "image interpretation". The other approach involves the use of a computer to examine each pixel in the image individually with a view to making judgments about pixels specifically based upon their attributes. This is called "quantitative analysis" because of its ability to identify pixels based upon their numerical properties.
In this paper we applied both techniques on a multispectral LandSat TM imagery of Lesvos island in order to extract land cover thematic maps and compare photointerpratation to digital analysis results.

AREA AND DATA DESCRIPTION

The study area is situated at the southeastern part of Lesvos Island (Fig. 1). The studied area is enclosed within (26,3532°, 39,2501°), (26,5329°, 39,2269°) and (26,3181°, 39,1122°), (26.4981°, 39,0888°) and covers an area of 209,684Km^2.

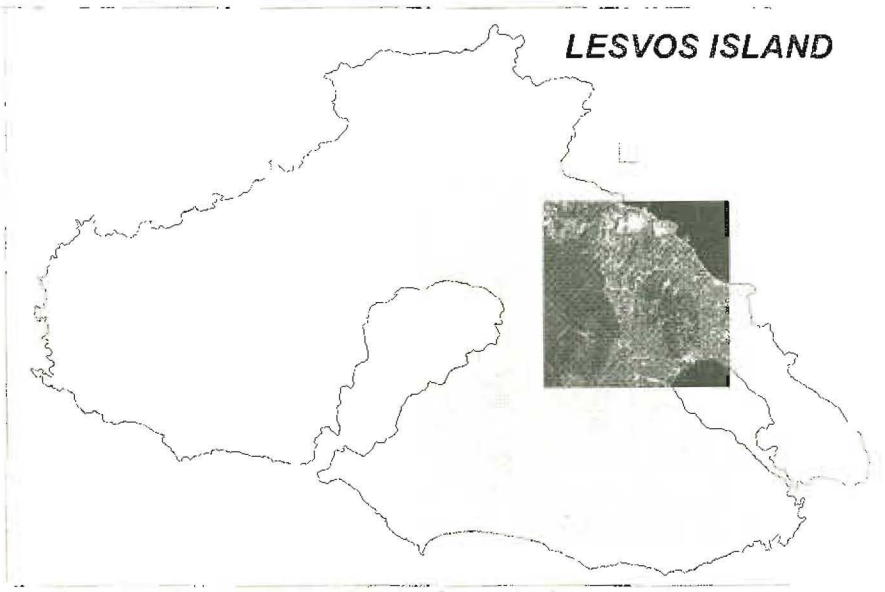


Fig. 1: The studied area

QUALITATIVE ANALYSIS

The satellite image has been georeferenced by adding control points at specific pixels of the image. In this way, we matched the image X,Y coordinates and earth's projection coordinate system, in our case Long/Lat system. Afterwards we separated the main landuses of the area, in separate boundary objects. These objects were stored in a GIS data file name 'Landuse.Tab'. In order to be able to compare the two methods the photointerpreter had to be restricted to three land cover categories as the algorithm of "quantitative analysis" was programmed to do. In order to photointerpreter we have to inspect the image color alterations having in mind the general land cover of the surrounding area. For example isolating various domestic areas of less than 5.000m^2 in the middle of a forest might be an error. In such case it is necessary to examine the specific area in larger scale. Firstly by stereoscopic observation and if necessary by field work. In cases of field work it is more efficient to digitize these small domestic areas, extract their X,Y, coordinates and locate them with the use of GPS in the field.

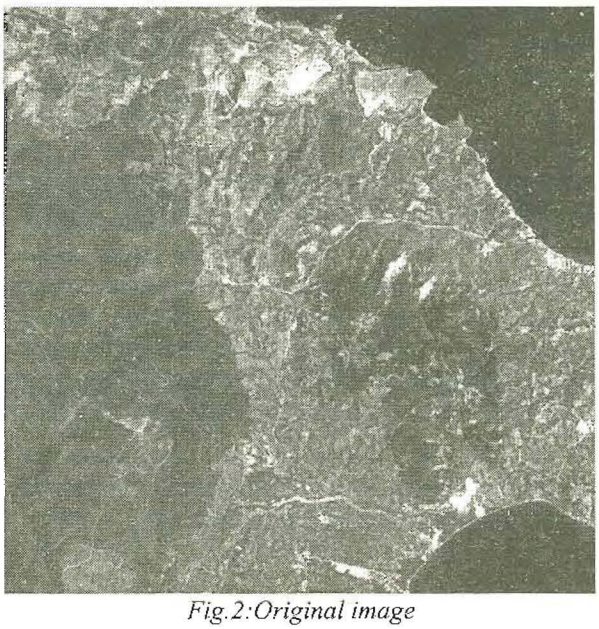


Fig.2:Original image

In most cases depending on the experience of the interpreter and the previous study of the area such detailed examinations are avoided. Photointerpreting the SE part of Lesvos island we separated different boundary objects and updated the corresponding data base with a set of information on each land use object. We used the original image shown in figure 2. The result of the land use classification in that way is shown in figure 3 where, 1 represents *forest, 2 agricultural areas* and 3 *inhabited areas-bare rock-quarries-land with less than 10% vegetation*. The above data were analyzed with respect to their geographical distribution, as shown in the corresponding thematic map (Fig. 3). In this map, we can distinguish the 3 main landuse categories. We also made a statistical analysis on the area (Km^2) of each object and each category.

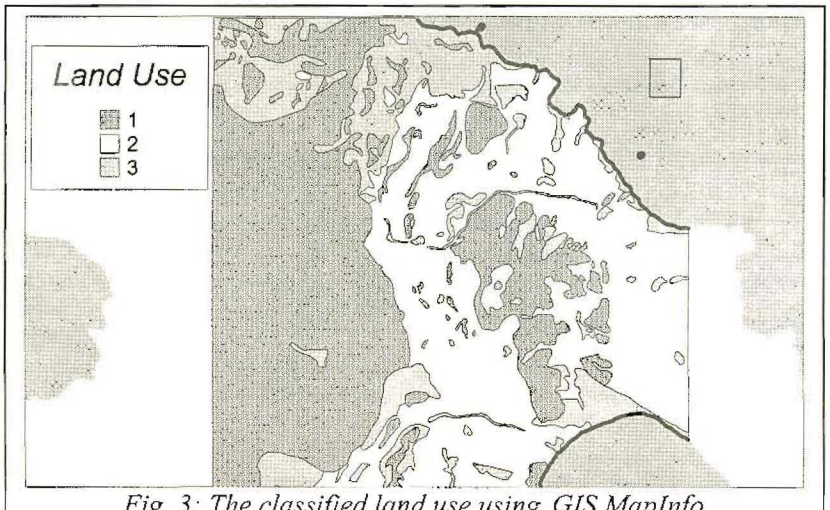
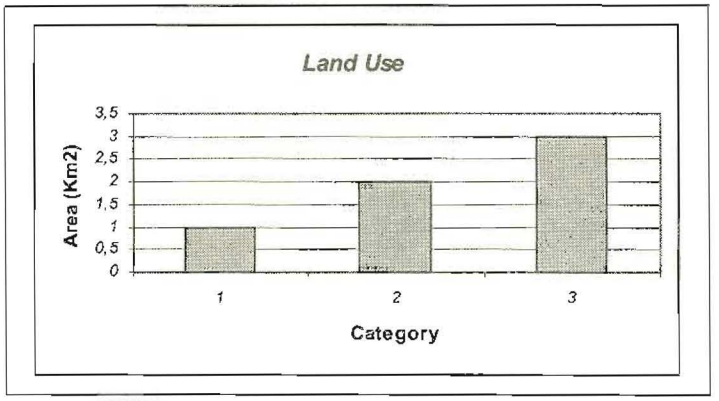


Fig. 3: The classified land use using GIS MapInfo

In the following diagram and Table I we have the area of each land use category in Km^2.

Table I	
Category	Area (Km^2)
1	93,9032
2	80,2242
3	35,5241



CLASSIFICATION USING NEURAL NETWORKS

Several techniques have been recently proposed for multispectral satellite image quantitave analysis. Such techniques include traditional statistics, neural networks and fuzzy logic. Specifically , artificial neural networks (ANNs) are very well suited to multispectral image classification mainly due to their processing speed, robustness, generalization capabilities and easiness to deal with high dimensional spaces [1,2]. ANNs can be distinguished in the following two general categories: a) supervised in which labeled training samples are used for parameter optimization and b) unsupervised using a data clustering algorithm

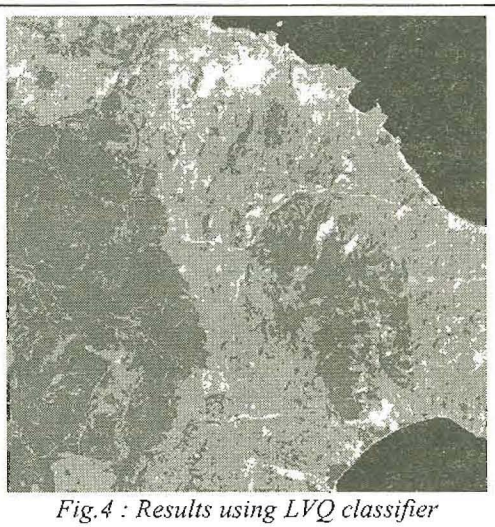


Fig.4 : Results using LVQ classifier

In this work we consider the following supervised classification techniques: a) a single-layer ANN trained with the LVQ algorithm [2], b) a multi-layer ANN trained with a variant of the backpropagation algorithm enhanced with constrained optimization techniques (the ALECO algorithm [3])

The goal is to classify the original image to the following 4 land-cover categories: *a) forest, b) sea, c) agricultural* and *d) inhabited areas-bare rock-quarries-land with less than 10% vegetation*. Two labeled sets of 6011 and 3324 samples from the above four categories, were selected by the expert for ANN training and testing their classification performance respectively. The land use classification was carried out using the "Artificial Neural Networks for GEOSIS Integrated Environment (ANNGIE)". *ANNGIE* is a prototype software tool, developed to aid geologists and geophysisists in tasks related to the exploration and identification of Nickel ore deposits.*ANNGIE* was developed in the frame of *GeoNickel* BRITE EURAM a project that brought together geo-scientists and computer scientists in an attempt to find innovative and efficient methods for identifying Nickel deposits.Figures 4 and 5 show the classification results obtained with the LVQ and ALECO algorithms respectively.

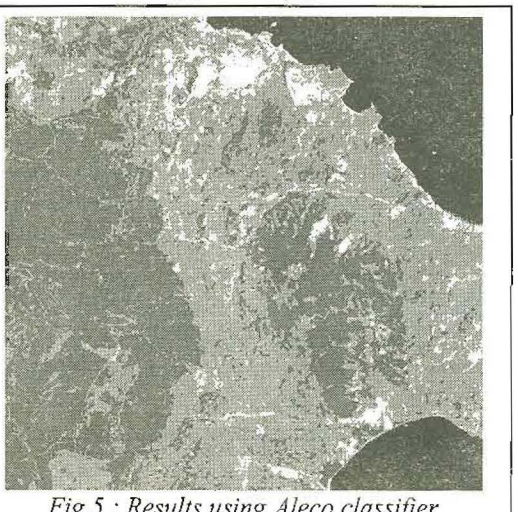


Fig.5 : Results using Aleco classifier

Training and classification times are shown in Table II.

Table II

Algorithm	Training time(sec)	Classif. time(sec)
LVQ	2.88	3.45
ALECO	62.95	9.92

RESULTS - DISCUSSION

The two approaches to image interpretation have their own role and are often complementary. Photointerpretation is aided substantially if a degree of digital image processing is applied to the image data beforehand, whilst quantitative analysis depends for its success on information provided at key stages by an analyst. This information very often is drawn from photointerpretation.
A comparison of the results shows that photointerpretation , involving direct human interaction is good with decisions about shape, size, orientation and texture but poor in quantitave accuracy. By contrast quantitave analysis has high ability in in quantitave accuracy.
By crosstesting the result maps of the two methods, mentioned above, we see that the algorithm is quite accurate when processing the 'forest' and 'sea' areas of the image. On the contrary, quantitative analysis often fails to distinguish categories of 'agriculture' and 'inhabited area – bare rock – quarries – land with <10% vegetation'. Examples of this problem, are visible at the north-western and south-western parts of the image. In order to improve the results of the 'quantitative analysis algorithm' the analyst needs to do more detailed training, as the overall characteristics of these two categories, are almost the same.
Basically, the overall classification results are encouraging. Neural networks were trained only in satellite imagery. Ancillary data would be very useful in order to be able to discriminate classes that were not classified accurately.

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